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FIELD EVALUATION OF TOPSIDE DECOMPRESSION MONITOR (TDM) DURING SHIPS HUSBANDRY DIVING AT SWRMC-NI

NAVAL SEA SYSTEMS COMMAND

Navy Experimental Diving Unit

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INTRODUCTION

To enhance the deployability, safety, and efficiency of U.S. Navy surface-supplied air diving operations, the U.S. Navy Supervisor of Diving (SupDive) is developing a Next Generation Dive System, a principal objective of which is to enhance the safety and efficiency of surface-supplied air decompression procedures. A benefit foreseen for ships husbandry divers is to take advantage of the multi-level nature of the dives using a Topside Decompression Monitor (TDM) system to prescribe diver decompression schedules in real time — according to depth-time profiles actually experienced by the divers, not according to costly conventions for rounding up required depths and times when such schedules are obtained from conventional decompression tables.

Naval Sea Systems Command (NAVSEA) tasked[1] Navy Experimental Diving Unit (NEDU) to enhance the prototype TDMs that had been used during operational dives in La Maddalena, Italy,[2] and to field-test the intermediate product to ensure that the modifications to the user interface are compatible with Fleet diving procedures. The purpose of the project was to test the form and function of the TDM as an operational system.[3] The first step was to evaluate the interface that allows divers to be tracked through multiple dives while a single TDM system was being operated in a unit. The primary objective was to compare the TDM's prescribed decompression times with those of conventional tables to demonstrate the benefit of the system. A secondary objective was to obtain informal end-user feedback about the system's configuration to improve its operating procedures (OPs). A NAVSEA waiver[4] authorized the Diving Supervisors to use the TDM's decompression prescriptions rather than the Air Decompression Tables from the *Navy Diving Manual, Revision 6*.[5]

METHODS

Two TDM systems (minus the laptops) were shipped in a collapsible pallet to Southwest Regional Maintenance Center–North Island (SWRMC–NI) two weeks before the planned deployment. NEDU representatives hand-carried the TDM laptops through the airports. After one touch screen failed upon arrival, an alternate laptop was shipped to SWRMC–NI to ensure that a complete backup system was available for the training.

Initial training including an overview of the TDM system's purpose, its components, and its software was conducted in the SWRMC–NI meeting room. During this initial meeting, diver information was entered for all attending SWRMC–NI divers. Supplied with gas from a scuba cylinder as a pressure controller to simulate dive profiles, the sensor verification box was used to demonstrate the TDM's operation during dives.

The following morning the TDM equipment was transported to the SWRMC–NI barge tied next to the USS NIMITZ. Two 650 ft sensor cables were married into the first 300 ft of Red and Green divers' umbilicals by being tightly wrapped around them in the same

manner as the cable for the lights, cameras, and communications. Wrapping a cable into an umbilical is a long, time-intensive operation for a full dive side. During the process of wrapping the second cable, the dive side discovered a gouge 50 ft from the end of the sensor. This damaged cable was unwrapped and replaced with an unused 650 ft cable.

To avoid interfering with normal diving operations, the pressure transducer for each diver was attached to the existing surface-supplied umbilical between the shackle and the helmet behind the diver (Figure 1).

Figure 1. Sensor placement on diver's umbilical.

On the barge, the components of the TDM were arranged to avoid interfering with diving operations. The sensor interface box (SIB) was located inside the door to the International Standards Organization shipping container next to the Fly Away Diving System (FADS) console (Figure 2). This arrangement allowed the cables to be routed along the umbilicals to the SIB without creating a tripping hazard. The long serial adapter cable was used to allow the TDM laptop to be placed next to the communications console (Figure 3) so that a single individual could manage communications and operate the TDM.

Figure 2. Sensor interface box placed inside van and next to FADS console**.**

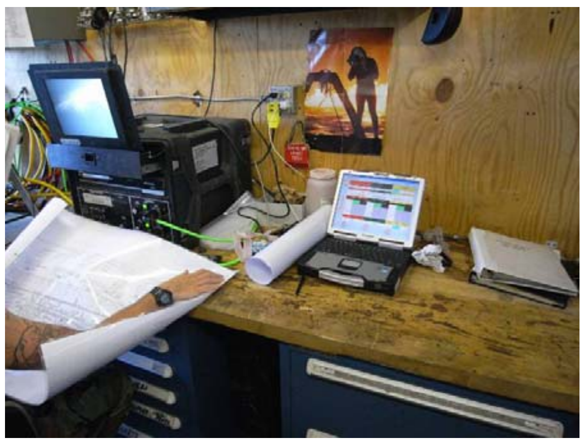

Figure 3. TDM laptop on desk next to communications console, to allow it to be operated in conjunction with communications.

A second dive side was set up in a portable dual axle trailer. For this second system, additional 650 ft sensor cables were laid slightly loose (to avoid taking strain), rather than wrapped, down the length of the umbilical and were taped every two to three feet to facilitate swapping out TDM cables, if that were needed. The first 50 ft of each cable was placed under the protective boot.

The components of the TDM were also arranged in the trailer to avoid interfering with diving operations. Since the gas storage banks had to be placed in the center of the trailer to avoid unbalancing the load placed on it, the trailer's layout differed from that of the barge. The SIB was located inside the back door, against the gas storage rack with the diver's umbilicals and helmets, while the laptop was set up in the front of the trailer on a bench next to the communications/logs console.

Both dive side setups took advantage of the longer serial cable to split the footprint of the TDM and reduce the impact on operations.

During setup of the trailer, the second SIB stopped functioning, so the working SIB was moved between the two dive sides until a replacement was received from NEDU. The shipment of this replacement was accompanied by six 350-foot backup cables.

Once the TDM was operational at both dive sides, training continued during operational dives, with decompression obligations being determined by Revision 6 of the *Navy Diving Manual*. Training was not deemed completed by the Diving Supervisors until all personnel had met the requirements laid out in Appendix A.

Two-thirds of the way through the reporting period, the 650-foot cables were removed from the divers' umbilicals in the trailer and were replaced with new 350-foot cables.

Because of problems with starting the TDM and with one sensor responding sporadically, a modification was made to the TDM executable to allow users to override the lack of sensor response while a dive was being started. Incorporated to aid in troubleshooting, this override notified the user of the lack of a sensor response and did not delay divers with working sensors.

Before each dive operation, the TDM was set up in accordance with OPs documented in Appendix B. Once all members of the SWRMC–NI dive side had completed training, sensor verification was performed daily during training and then before the first dive of the week. The dives then proceeded as scheduled, with the pressure sensor securely attached to the umbilical and close to the monitored diver's chest level. The secondary data logger remained securely fastened to each diver's umbilical in the same general area. Diver depth/time profiles from the TDM were archived at the end of each week, and copies were made of the paper dive charts by the NEDU representative on-site. The secondary data loggers were swapped out every two weeks and were returned to NEDU at the end of the period covered by the test plan. Failure of the TDM at any time did not result in dive termination.

Once the TDM was operational, its primary backup was the Thalmann Algorithm Dive Planner, v4.02. The second TDM laptop was used to have the Dive Planner available if the primary laptop failed. Operation of the Dive Planner required noting the maximum depth or recording the dive as having multiple segment depths to perform multilevel calculations. The final TDM emergency procedures (EPs) had not yet been completed; SWRMC–NI divers had been entering dives as segments into the Dive Planner on a second laptop to enhance the initial EP of recording the dive segments in the smooth log.

To take advantage of the training conducted at SWRMC–NI and its upcoming diving schedule, the TDM was fielded for an addition year under a NAVSEA waiver.[6] Two TDM systems were left on-site to be used by a qualified dive side,[7] with NEDU providing technical support.[8] The results of the TDM evaluation at the end of this one year of fielding will make its operational ability more representative and should highlight where additional improvements to the system and the training package are needed before widespread use of the TDM begins.

EXPERIMENTAL DESIGN AND ANALYSIS

The TDM prototype was set up for field-testing and run on an operational dive station to obtain feedback to improve the devices. The Diving Supervisor was to use the information obtained to determine a diver's decompression schedule, according to the bounds of a NAVSEA waiver.[4] Divers incurred no additional risk due to implementation of the test procedures over using the Thalmann Algorithm Dive Planner v4.02. The pressure transducers used were attached to the already-used surface-supplied umbilicals and did not interfere with normal diving operations. The monitored diver depth/time profiles recorded by the TDM were logged to data files. The actual decompression was also recorded for a comparison between the decompression guidance of the Navy Diving Manual to that indicated by the TDM. In accordance with the NAVSEA waiver, the Thalmann Algorithm Dive Planner was used as the primary backup for the TDM's decompression guidance.

Once the TDM was set up, the dives went as scheduled, with the pressure transducer securely attached at the monitored diver's mid chest level. The secondary data logger (DDR-200) was securely fastened to the diver and as close to the TDM sensor as possible.

The primary outcome of the study, via a comparison between actual decompression times completed by the divers and the allowed decompression limits of Revision 6 of the *U.S. Navy Diving Manual*,[5] aimed to determine decompression time savings.

The secondary outcome of this field trial was to update OPs that cover sensor verification, daily setup checks, database backups and recoveries, battery swapping, and updating executables.

INSTRUMENTATION

The following equipment was used during testing:

1. Two TDM systems running an updated prototype version of the software and using eight Honeywell model PPTR0300AP5VB pressure and temperature transducers, with one transducer per diver (red/green = two per dive) and two transducers as spares for each dive side; and

2. Ten Cochran Undersea Technologies DR200 data loggers (each of which was changed every three to four weeks) — one for each diver's umbilical.

RESULTS

A total of 53 man-dives were completed with the TDM on station. Of these dives, three had missing smooth logs, 10 had no TDM file, and 15 had incomplete or unusable TDM files. Both smooth logs and usable TDM records (summarized in Appendix C) remained for 28 dives, an overall capture rate of 52.8%. For 14 man-dives, the main purpose was that of TDM training. For additional dives conducted by SWRMC–NI, the Dive Supervisor chose not to use the TDM; only dives for which the TDM was chosen for use are documented in this report.

One of the corrupt data files had a 12-minute interruption, when the TDM was stopped to change Green divers. During this interruption, the Red diver descended from 23 ft to 31 ft. With a gap in the profile for the Red diver the guidance from the TDM is not usable. Noting the time at which the descent was made would allow for the Dive Planner to be used to maintain the benefits of real-time decompression tools. The TDM’s inability to change out divers in one position while the diver in another position is underwater limits its flexibility, particularly during ships husbandry.

During the first week on-site, NEDU representatives, a NAVSEA Master Diver (MDV), and the MDV at SWRMC–NI discussed the training requirements necessary for personnel to be considered qualified to operate the TDM. The training requirements to which all these representatives agreed are provided in Appendix A.

During training, the OPs were modified to make them clearer and easier to use; these resulting procedures are provided in Appendix B. Additional temporary instructions and procedures were written to cover requirements not yet incorporated in the software, and Appendices D through G provide these in the same formats as they were used at SWRMC–NI.

The final product of this NEDU test plan[3] is a fully trained dive side[7] that has permission to operate the TDM for an additional year under a NAVSEA waiver[6] — with an NEDU agreement to provide technical support[8].

DISCUSSION

During the initial training session at SWRMC–NI, the touch screen of one of the CF-29 Panasonic Toughbook laptops was discovered to have failed. This laptop, which one of the authors had carried, had not undergone any additional jarring beyond that which the non-Toughbook laptop carried in the same case had experienced. While an alternate laptop was being readied for shipment to SWRMC–NI, a second of the four TDM laptops was also discovered to have a faulty touch screen. Toughbook laptops have presented NEDU with previous negative experiences — e.g., as a part of the Mission-Related Performance Measures System Project,[9] an experience that NEDU has recently documented in a technical memorandum.[10] In the author's opinion, the Toughbooks are overrated, and an alternate, more robust laptop should be selected for TDM systems in production.

On the sensor cable with damages discovered during the wrapping process, two conductors were discovered to be bare and corroded — damages not caught by the inspection at NEDU but likely to have resulted from the use of these cables in La Maddalena. All the cables shipped to SWRMC–NI had been electronically inspected for conductor resistance and insulation impedance, but neither of these tests had detected a fault. Thus, these tests are insufficient to discover physical damage: A better cable inspection process is needed.

For a field trial, the wrapping process was found to be an unnecessary use of manpower. Originally it was thought that a wrapped cable would share degrees of stress or damage equal to those of other elements of the diver's umbilical and would thus offer suitable protection to allow long-term function. The first umbilical failure that lost some TDM dives was that of a light and camera cable, a failure which caused an alternate umbilical that had not been outfitted with a TDM cable to be used. If the TDM cable had been easier to wrap, fewer dives may have been lost. Provided the cable is under the 50-foot protective cover, there is no evidence that taping the cable to the side of the diver's umbilical caused failures that would not have occurred with a cable wrapped into the umbilical.

The effort involved in removing and replacing the 650-foot cables with 350-foot cables for the portable trailer was much less than it would have been for wrapped cables. Two individuals completed the process in one afternoon. Cable damage is inevitable; if the labor overhead of swapping cables exceeds the value added by the TDM, then the system will not be used.

The benefits that can be realized from using the TDM include improved efficiency through time savings from decompression calculations based on real-time depth profiles and on nontabular surface interval calculations. These benefits will be observable in ships husbandry diving: Such a diver will be enabled to pick up a dropped tool or to investigate a single discharge, inlet, or opening at depths greater than those previously realized without any additional divers having to be added to the operation to avoid exceeding his no-stop limits. More important, on two occasions the TDM enabled divers

to avoid a decompression requirement when they became fouled and were forced to descend. This multilevel benefit was verbally reported by the divers and supervisors of SWRMC–NI: During training dives, Dive Supervisors demonstrated this benefit to themselves by having divers change their depths to simulate tool drops while the Supervisors observed the remaining no-stop time displays on the TDM screen.

The causes of the low overall data capture rate during the observation period are also important to identify. The identified problems include the failure of an SIB box to recharge, broken wires in the 18-inch end whip of the 650-foot sensor cables, and a bad connector on an SIB. Although it is impossible to verify that these are the only causes of the intermittent signal loss, the identifiable causes must be eliminated so that any additional ones may be observed.

The problem of the noncharging second SIB box was found to result from a metal shaving shorting out and destroying one of the power supplies. It is presumed that the shaving had been introduced while a replacement metal faceplate was being refitted just before the operation.

The 650-foot cables from La Maddalena were used initially for this fielding, and they remained in use during diving from the barge. One setup difference between the 650- and the 350-foot cables is in how connectors were added to the sensor end of the cable. For the 350-foot cables, a metal-bodied connector was potted directly to the end of the blue Remotely Operated Vehicle-style robust cable. For the 650-foot cables, a connector on the end of a 12- to 18-inch, highly flexible but thinner cable was potted to the end of the same style of robust cable. Within a few weeks, SWRMC–NI divers during sensor validation were able to demonstrate sensor communication problems due to the different orientations of this cable's whip section. All cables should therefore have connectors potted directly to the end of the cable without the thinner flexible section. Six 350 ft cables were shipped to SWRMC–NI for use with the shorter umbilicals available from its portable diving trailer.

The third SIB also had problems with intermittent sensor signals, which were reduced when this box was replaced with the first SIB box. The cause of these problems was found to be two separate faulty components: One of the 650-foot cables had intermittent connectivity when the 18-inch whip end was in varying positions, and one of the connectors on the back of the SIB would not work reliably. This connector would work with brand new cables at NEDU, but it was not working with connectors that were visibly tarnished.

After the experience in La Maddalena,[2] a protector frame was added to ensure that the sensor cables could not be disconnected from the box. No accidental disconnections of cables were observed during this fielding, but intermittent communication problems were observed. After only a short time (30 min) running on batteries in the workup before this fielding, the TDM's SIB was found to be unable to power both the laptop and the sensors without an intermittent signal loss occurring. The low battery voltage could have caused the intermittent signal loss during the La Maddalena operation. To prevent

such power siphoning from causing these intermittent loss of signal problems during this operation, the cables that allow the laptop to siphon power from the SIB were not supplied to SWRMC-NI.

The most common hardware problem continues to be observed as an intermittent to continuous loss of sensor signal. In only a few cases were the hardware failures due to poor connections between the end of the cable and the control box. This problem of intermittent to continuous loss of sensor signal appears to result not from disconnection but from dirty contacts or from internal damage to the connector. With strain relief brackets in place, no problems with disconnecting the cables from the SIB were observed. We had hoped to have a nonaerosol contact cleaner whose material safety data sheet indicated that it would not require hazmat handling, but a request to have the contact cleaner declared as nonhazmat was never returned. The TDM will need to have a contact cleaner as part of its standard package.

Another problem is that the quick-disconnect chosen to link the end of the sensor to the pressure verification box has a hole diameter that, due to surface tension, traps water. To clear the water, an object such as a toothpick must be inserted into the opening. To keep the sensors from corroding, we need either to identify a quick-disconnect of a larger size or to identify a solution that dries the inside. Quick-disconnects on both the verification box (female) and the sensors were changed to fittings with ⅜ -inch internal diameters, and these prevented water retention against the pressure sensing membrane.

Still another problem associated with using the TDM during ships husbandry will be that of the sensor port becoming clogged with mud or silt from the bottom — or with the Bintsuke that is used to seal cofferdams to ships' shafts. Bintsuke, a sticky substance used to plug holes and keep water from entering between the patch and the vessel, must be kept away from the sensors: Clearing a clogged sensor underwater is already difficult, due to its position and the small size of the opening. M16 double magazine pouches were purchased from a surplus store and modified to make pouches to protect sensors. A hole was cut in the bottom of the pouch to allow entry of the sensor cable, and the Velcro closures at the top of the pouch made the sensor accessible for verification or cleaning. Foam padding (¼-inch plumbing insulation) was added to the sensors to reduce damage from impacts (Figure 4).

Figure 4. Foam-protected sensor and M16 double magazine pouch.

Some of the reason for having little data recovered from this fielding is that the waiver was delivered following a major period of ship availability. The summer did provide a good time to provide training, but it was not the most cost effective for obtaining operational ships husbandry dive profiles. A waiver extension that allows the TDM to be used for all of FY11 has been granted,[6] and following this extended period that starts with a trained crew, a collection of dive profiles that provides a more accurate summary of the benefits of the TDM should be available. This continued fielding will improve the cost effectiveness of the effort to collect operational dive data. During the next fielding of the TDM, rather than sending NEDU representatives to cover the entire period, we will consider sending a training crew for two to four weeks to get the local dive side proficient in operating the TDM. This training period should be scheduled during a slight lull (non-24/7 operations), but with a sufficient number of dives to gain experience before the dives of interest are begun. This fielding procedure would permit a lower cost method of leaving a prototype TDM system in place for an extended time to record data from dives with schedules subject to operational considerations beyond those of our evaluation.

As a result of the problems observed in the La Maddalena fielding,[2] a robust training program including instruction in both OPs and EPs was recommended. Draft procedures were created before the TDM was shipped to SWRMC–NI, and these procedures were modified and expanded to answer questions and situations identified by the SWRMC–NI dive side. The procedures covered proper setup and deployment, software interface, backup power options, and database backup and recovery (See Appendixes B, D–G). TDM operators also required training in using v4.02 of the Thalmann Algorithm Dive Planner,[11] the primary backup to the TDM.

One of the OP steps was to verify that the sensors were functioning correctly. To verify that they were providing an accurate depth reading, a sensor verification box (SVB) using gas supplied by the “come-home” bottle and a pressure regulator supplying pressure to the sensors were incorporated. The sensors were fitted with a brass quick-disconnect nipple that allowed a gas-tight seal with the SVB. A verification check

window, accessible through the TDM's configuration screen, was used to match sensor readings to supplied pressures at 6 pressures. One downside to the initial configuration of the SVB was that the sensor needed to be oriented vertically above the SVB in order to perform the verification (Figure 5). The process of verifying a sensor while it remained attached to the diver's umbilical placed unnecessary stress on the flexible whip ends that had already been identified as weak points. A 10 ft adapter cable with a three-way split allowing simultaneous connection of all three sensors reduced the stress on the cable as well as the overhead on the dive side.

Figure 5. Diver setting up sensor verification. Care was needed to avoid excessive stress on the cable during verification.

A recommendation from the fielding in La Maddalena had been to make the connectors on the ends of the cables the same, so that the sensors could be plugged directly into the SIB for troubleshooting. The recommendation was intended to avoid using cumbersome spare 350- to 650-foot cables to conduct a sensor test that requires unnecessary effort. Short 3- to 6-foot testing cables that improved the users' ability to determine when a cable was the cause of an intermittent sensor signal loss were provided. In one case when both a bad cable and a faulty SIB connector occurred, however, the short cables were insufficient to isolate the problems. A troubleshooting

guide that enables problems to be isolated and good components to be verified step-by-step needs to be created.

The SWRMC–NI dive locker considered many of the dives to be familiarization (FAM) dives, since they were being conducted to enable divers to become proficient in operating the TDM. Divers were to be considered as qualified TDM operators after they had demonstrated their proficiencies during a dive. Since a large ship availability had just been missed, the dive locker experienced a reduced frequency of dives — and the MDV at SWRMC–NI and the Dive Supervisors were not prepared to use the TDM as a primary system until late in the reporting period, after all divers had been trained as TDM operators. The operational dives conducted after these FAM dives did not highlight the benefit of multilevel diving that the TDM has to offer. The dives anticipated for ship availabilities in FY11 should highlight the usefulness of the TDM's flexibility.

During times when one sensor frequently provided intermittent signals but the other did not, the TDM could fail to start (to initiate its dive mode), since the software required that a sensor respond for each diver during the transition. To allow testing to continue for divers with responding sensors, an override was added to the program. This override notified the user that a sensor had failed to respond during the startup sequence and (if the total number of divers that had been entered into the software was greater than that which had physical sensors) asked whether it was OK to continue. This updated executable, along with the procedure in Appendix G, was mailed to the on-site NEDU representative to replace the current TDM executable.

During the fielding time, the TDM was not used for some dives for various reasons: some dives were not being conducted as surface-supplied, the planned dive depths and times did not justify the TDM's setup, it was not functioning reliably during setup, or it was unable to start if either sensor was failing to communicate at the time the start button had been pressed. After the switch to 300-foot sensor cables by the end of the reporting period, the TDM was starting to perform reliably. Increasing the reliability of sensor communications needs to be a high priority, and the most cost effective method to continue TDM development and testing is to have NEDU focus on software development testing and to select a vendor to manufacture the hardware.

The SWRMC–NI divers provided written feedback midway through training, and most of this feedback contained comments that the addition of multilevel capability would be beneficial in ships husbandry. Many divers complained that the time required to verify the TDM sensors was excessive because each sensor had to be verified individually, and they requested a method to enable simultaneous verification of all three sensors. As a result of this feedback, a 10-foot, three-way adapter enabling all three sensors to be verified simultaneously (and also to reduce the strain on the ends of the cables) was created. An additional complaint raised the problem posed by a TDM once a sensor had become plugged by debris: Since placement of the sensor behind the diver's back had made it difficult or impossible to clear, the sensor's mounting location was changed to the diver's chest, to improve his or her ability to clear debris without assistance. At both the dive and the operation levels, Diving Supervisors and both of the SWRMC–NI

and NAVSEA MDVs requested a method to add notes that could be used to document exceptions or information about the job being performed.

CONCLUSIONS

Limitations in both the hardware and software of the TDM prevent it from being considered a finished product in its current configuration. The next step for the hardware is to be put out to bid for production on the basis of the requirements set out in a forthcoming (in-press) NEDU technical report. Before the software is considered to be that of a nontesting version, some features need to be added to it — features such as: enabling divers to be changed during a dive, tracking surface decompression, launching the Thalmann Algorithm Dive Planner, communicating with the Navy Dive Computers, and verification validation and accreditation (VV&A).

Following this fielding (and with no NEDU personnel remaining on-site in the future), dive side personnel are sufficiently trained to use the TDM as a decompression tool under a waiver extension.[7]

The TDM shows great promise as a means to improve the efficiency of operational Navy diving through its monitoring of real-time depths and calculating of decompression obligations.

RECOMMENDATIONS

A robust laptop needs to be selected for the production TDM systems. A model with a touch screen that has demonstrated reliability during field use by personnel including those of Explosives Ordnance Disposal, SEALs, Coast Guard (small boat), or Marines should be suitable.

From the data obtained during this study and the requests of on-site personnel for implementation of the TDM’s use, we recommend that the TDM be advanced to the next phase of development. Required next steps include enhancing the software’s capability to track dives through surface decompression, launching the Dive Planner, enabling divers to be changed during a dive, transferring dive data to an archival database, and verifying the software through a formal independent verification and validation process.

While the software is being enhanced and validated, the TDM hardware should be finalized and limited production started. The system needs to be made more rugged and reliable than it is. Issuing production TDM hardware to selected units would enable multisite testing that can be transitioned to a wide-scale field trial as the software approaches a final version.

To enable simultaneous running of the Dive Planner to act as the primary EP when a TDM fails, a second laptop should be added to the load-out list for a TDM system.

A troubleshooting guide enabling step-by-step verification of good components to isolate problems within the TDM system needs to be created.

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Appendix A: TDM Training Requirements

NAVSEA/ NEDU Topside Decompression Monitor Training Requirements

Topside Decompression Monitor (TDM) Operators must attend orientation and operate TDM on a minimum of three dives.

Dive Supervisor must attend orientation and be familiar with the operation of the Topside Decompression Monitor.

Training will be documented and kept in command training jackets.

Feedback is required to NAVSEA via the on-station NEDU representative. Forms will be provided by NEDU staff.

TDM Orientation:

Give purpose of TDM (What is benefit to dive locker)

<u>Hardware orientation</u>

Show all of the Topside Decompression Monitor (TDM) components

1. Pressure/Temperature Sensor
2. Sensor connector
3. Sensor cable
4. Sensor Interface Box (SIB) connectors
5. Serial Cable to computer
6. Power cable
7. SIB connector protector
8. Sensor Interface Box (SIB)
9. laptop and serial connector (touch on battery and power cord)
10. Sensor verification equipment that doubles as over bottom verifier for EGS

<u>Software orientation</u>

1. Go through each field associated with the windows opened with the following buttons:
   a) Administration
   b) Configure
   c) Divers
   d) Operation
   e) Operation roster

Demonstration of simulated dive (with gas bottle and dive planner)

Questions and Answers

Appendix B: TDM Operating Procedures

<table>
<tr><td colspan="2">Date:</td><td colspan="4">Mission/Dive Identifier:</td></tr>
<tr><td colspan="6">Note:</td></tr>
<tr><td colspan="2" rowspan="2">Procedures:</td><td colspan="4">Initials</td></tr>
<tr><td>Red</td><td>Green</td><td>Yellow</td><td>X-tra</td></tr>
<tr><td colspan="2"></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">1. Ensure that TDM is setup and complete
1. Marry sensor cable with diver umbilical in accordance with US Navy Umbilical Manual
2. Connect sensor to sensor cables
3. Connect sensor cables to Sensor Interface Box (SIB)
4. Connect SIB to computer
5. Connect SIB to power source
6. Connect Computer to power source
7. Power on SIB
8. Power on computer</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="6">NOTE: Leave enough slack on surface side to safely secure and maneuver SIB</td></tr>
<tr><td colspan="2">2. Place computer in position of readiness.</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">3. Place SIB in position of readiness and secure in position.</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">4. Ensure computer is safe from sea and sun.</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">5. Start TDM program
• Login to laptop as TDM user (no password)
• Double clicking on the “shortcut to VVAL18” icon on the desktop.
• Enter the UIC and station number for the dive side
• Enter Dive Side Administrative Information if it has changed</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">6. Open Configuration Widow of TDM
• Enter or Verify the Serial Number of the sensors for each dive position that will be diving</td><td></td><td></td><td></td><td></td></tr>
</table>

Procedures:	Initials			
	Red	Green	Yellow	X-tra
6. Cont. To Add a New Sensor: a. Disconnect the sensor cables for the other 2 sensors until completed b. Enter the Sensor Serial Number and click Set. c. Reconnect the disconnected sensor cables • Zero each sensor (14.7 to 15.1 psi absolute at surface).				
7. If this is the first TDM Operation of the week, the Verify the TDM Sensors. 1. Open TDM Sensor Verification Window 2. Hook Gas Supply to Sensor Verification Box (SVB) 3. Set valve V-1 to Direct 4. Set Valve V-2 to Gauge 5. Open Gas Supply Valve 6. Turn Valve V-2 to vent and return to Gauge to ensure flow. 7. Check that gas supply pressure exceeds 100 psi to be sufficient to conduct verification test 8. Switch Valve V-1 to Control 9. Back out Pressure Regulator (PR-1) 10. Open and Close Vent bringing gauge pressure to zero 11. Bring Pressure delivered to Sensor by Verification box up to be between 4 and 8 psi by slowly turning PR-1 clockwise. Vent as needed to lower pressure. 12. Enter Pressure read from gauge on TDM Verification Window (for the appropriate range) 13. Click on Verify button for the sensor(s) that are having pressure applied to them. 14. Ensure that the TDM returns a message that the reading was acceptable – if not, trouble shoot problem				

Procedures:	Initials			
	Red	Green	Yellow	X-tra
7. Cont. 15. Repeat steps 11 through 14 for pressure ranges of: 8 to 12 psi 20 to 24 psi 42 to 46 psi 64 to 68 psi 98 to 102 psi 16. Repeat steps 9 through 15 as needed for green and yellow divers sensors. 17. Disconnect all sensors. 18. Remove Pressure Supply from Verification Box 19. Vent Verification Box 20. Close the Verification Window				
8. Verify that sensors see atmospheric pressure by clicking on the Refresh button (14.7 to 15.1 psi). • Close the Configuration Window				
9. Ensure all divers are available in laptop • Add if not present				
10. Enter the Dive Operation • Open the Operation Window • Select Operation if already entered, otherwise add a new operation. • Enter the details of the Operation and click save • Close the Operation Window				
11. Prepare the TDM to Dive • Open the Operation Roster Window • Select The Operation from the pull down menu (automatically selected if operation was just added) • Select the divers that will be diving from the pull down list for each of the three operation (but only for positions that have sensors configured)				

Procedures:	Initials			
	Red	Green	Yellow	X-tra
12. Start the Dive • At the direction of the Dive Supervisor click the Start Operation button. This can be done after the in-water checks to keep dive time synchronized with the Supervisors watches.				
13. Conduct the Dive according to the Dive Supervisors Instructions. • Provide remaining no-stop times as requested				
14. Post Dive • Once the Divers have reached the surface the Diving screen may be exited using the Close button.				
15. Close the Operation Roster				
16. If another dive is to be conducted repeat steps 10 to 14 as necessary.				
17. Backup the TDM Database • Open the Administration Window • Click on the Manage Database Button • Login • Click on Backup Database • Select E:[Backup] (PCMCIA card) • Click Ok on Message that indicates Backup is starting. • Click Ok on Message that indicates Backup completes successfully. • Repeat Backup with 2nd PCMCIA Card • Select F:[Backup] (PCMCIA card) • Click Ok on Message that indicates Backup is starting. • Click Ok on Message that indicates Backup completes successfully. • Exit the Database Management Window				
18. Exit the TDM Program				

<table>
<tr><td rowspan="2">Procedures:</td><td colspan="4">Initials</td></tr>
<tr><td>Red</td><td>Green</td><td>Yellow</td><td>X-tra</td></tr>
<tr><td>19. Shutdown the laptop
• Select Start->Shutdown
• Click on Shutdown
• Remove Power Cable from Laptop
• Remove Serial Cable from Laptop</td><td></td><td></td><td></td><td></td></tr>
<tr><td>20. Turn off SIB Box</td><td></td><td></td><td></td><td></td></tr>
<tr><td>21. Post Dive
• Rinse the TDM Sensors with fresh water
• Ensure that water is not left in the end Orifices.</td><td></td><td></td><td></td><td></td></tr>
<tr><td>22. Store the TDM
• The TDM System may be left connected between dive days if it has been setup in a secure location.
• Otherwise, disconnect the TDM Cables from the SIB and cap all connectors.
• Store sensors with orifices facing downwards to dry.</td><td></td><td></td><td></td><td></td></tr>
<tr><td>23. Recharge Batteries if needed
• Plug SIB box into secure power
• Plug TDM Laptop in to recharge on-board batteries
• An External Battery Charger is provided to charge one Primary Laptop battery using the large connector, and a Secondary battery using a small connector. Note: Battery charger uses the same power cable as the laptop.</td><td></td><td></td><td></td><td></td></tr>
</table>

Appendix C: Data Summary

Date	Start Time	Smooth Log Red RNT	Red Depth	Red Bottom Time	Red Rep Grp	Green RNT	Green Depth	Green Bottom Time	Green Rep Grp	Deco Time Avoided (min)	TDM data	Purpose	Comments
06/17/10	15:38		61	38	I		61	38	I	0	2	Training	Red Diver - Caused depth spikes by pressing against end.
06/21/10	12:26		60	42	H		60	42	H	0	2	Training	
06/22/10	16:14		39	55	G		39	55	G	0	2	Remove 2&4	
06/24/10	11:50		40	79	I		40	79	I	0	2	Swim By	Red diver intermittent loss of sensor response. Only a few for green
06/24/10	13:19	79	40	59	N	79	40	59	N	0	2	Swim By	Red diver intermittent loss of sensor response (less than previous dive).
06/30/10	11:22		52	32	F		52	32	F	0	2	Training	File has 2 headers
07/09/10	10:12		35	14	A		35	14	A	0	0	Drill	Only a single incomplete file,
07/15/10	10:30		45	12			45	12		0	2	Training	
07/20/10	13:02		29	239	N		29	239	N	0	0	Shaft Seal	Red Diver significant node loss Green Diver significant node loss
07/20/10	18:11		29	55	E		29	55	E	0	0	Shaft Wrap	no header, file starts at depth
07/21/10	8:47		33	81	H		33	81	H	0	0	Shaft Seal	first 5 min missing
07/21/10	15:08		33	173	N	33	33	173	O	0	0	Shaft Seal	Green Repeated
07/21/10	18:20	15	33	149	M		33	149	M	0	0	Shaft Seal	
07/31/10	9:38		30	229	N		30	229	N	0	1	Shaft Wrap	TDM has only 1 file - second sensor not functioning - intermittent signal loss
08/01/10	12:07		31	202	O		31	202	O	0	0	Not Noted	late starting - significant sensor signal loss
08/04/10	10:34		30	121	I		30	121	I	0	0	Shaft Wrap Removal	NO TDM files

Smooth Log										Deco Time Avoided (min)	TDM data	Purpose	Comments
		Red				Green							
Date	Start Time	RNT	Depth	Bottom Time	Rep Grp	RNT	Depth	Bottom Time	Rep Grp				
08/10/10	10:10		55	21	D		55	21	D	0	0	Training	Smooth Log Notes as 1 of 3 significant data loss both sensors
08/10/10	11:00		55	25	D		55	25	D	0	2	Training	Smooth Log Notes as 2 of 3
08/12/10	10:35		30	244	N		30	244	N	0	0	Shaft Seal	
08/20/10	10:26		29	135	J		29	135	J	0	0	Shaft Painting	TDM Error noted on smooth log Two files per diver, both start at depth
08/23/10	11:10		58	54	J		58	54	J	0	2	Salvage Antenna	Intermittent signal loss
08/26/10										0	1		Red Diver Infrequent missing nodes Green Diver has many missing nodes with huge gaps
08/30/10	10:49		31	193	M		31	193	M	0	2	Chase Leaks	
08/30/10	14:21		33	244	Z		33	244	Z	0	2	Chipping & Sanding	
08/31/10	10:11		30	283	O		33	30	O	0	1	Shaft Lamination	Red Data files split in two - time in filenames used to combine - 12 min missing (Two Green Divers, Name Changed)
08/31/10	10:58						34	101	O	0	1	Shaft Lamination	2nd Green Diver for above profile
09/01/10	11:16		35	115	J		55	110	J	34	2	Shaft Lamination	74 min no stop - Green dropped tool, recovered and avoided 51 min of deco.

Appendix D: TDM Laptop Battery Swap Procedure

TDM - Battery Change Procedure

This procedure is to be executed when a primary laptop battery is about to be deleted, in order to keep the TDM from being shut down.

Note: The CF-29 Laptop used in the TDM is capable of holding 2 batteries: 1 primary battery, and a secondary battery in place of the CD/DVD drive. When both batteries are placed in the Laptop at once, the Laptop runs off the secondary battery first.

Procedure:

1. Verify Battery Capacity
    - Click on Battery Icon on the right side of the Widows Task Bar to open the Power Meter Window (along bottom of screen)
    - Verify that the percent remaining for the batteries

2. Remove the CD/DVD drive from the media bay (left side of laptop).
    - Unlock the Media bay hatch by sliding the switch
    - Pry Open the media bay hatch with a fingernail
    - Open the sliding panel in the bottom of the laptop to reveal device release
    - Push device release towards media bay hatch
    - Pull out CD/DVD or expended battery from media bay
    - Close the sliding panel on the bottom of the laptop
    -

3. Insert the Secondary Battery (same shape as CD/DVD drive)
    - Close the Media bay Hatch
    -

4. Verify that the Secondary Battery is Charged
    - Open the Battery Capacity Window as in Step 1.
    - If battery indicator for 2nd battery is not greater than 15%, then do not proceed with swap using this battery (15% would allow swap of primary battery without shutting down laptop).
    -

5. Remove the Primary Battery
    - Unlock the Primary Battery hatch (forward of the Media Bay) by sliding locking clasp forward and down.
    - Open the Battery Hatch
    - Pull on Battery Tab to Remove

Procedure Continued:
6. Replace Primary Battery • Slide a Charged Primary battery into the open bay contacts first • Close Battery Hatch • Lock Battery Hatch by sliding clasp up and back.
7. Verify Battery Capacity is Sufficient to Run TDM • Open the Power Meter Window as in Step 1. • Verify that battery capacity indicators are higher than for batteries that are removed; should be greater than 95% for fresh batteries. • Verify that the estimated total time remaining is sufficient to complete TDM operations (or that additional batteries are available). • If estimated total time remaining is insufficient, and additional batteries are not available, note needed information from TDM in order to plan dive using the Thalmann Algorithm Dive Planner, or Revision 6 of the Navy Diving Manual.

Appendix E: Configuration Window – Sensor Pairing

Configuration Window – Sensor Pairing

Upon opening the Configuration Screen, Verify the sensor serial numbers for the sensors that will be used using the following process. The process of matching a physical sensor to a diver position will be referred to as "pairing".

Conduct the following for each diver in turn

- Ensure that the Serial Port Number is correct for the current laptop
- Ensure that the cable for the sensor being paired is connected to the Sensor Interface Box (SIB)
- If a serial number is visible for the current diver and matches the serial number of the sensor that will be physically connected to this diver
  - Click on the zero button on the row with the sensor serial number
  - If the sensor is successfully zero'd (no error message), proceed to the next diver
  - If there was an error attempting to zero the sensor, repeat the attempt to zero the sensor
    - If an error occurs during zeroing of a sensor, the Serial Number may be blanked out, and the Zero button made inaction – if this is the case, it is necessary to click on refresh to find the sensor and reactivate the button
  - If repeated attempts to zero the sensor are not successful, then attempt to pair the sensor as if the serial number was not present
- If a serial number is not visible or does not match the serial number of the sensor that will be physically connected to the this diver
  - Enter the Serial Number of the Sensor in the Box provided for the diver
  - Disconnect the cables for the sensors that are not being paired
  - Click on the Set button next to the entered serial number
  - If there is an error message, double check that this sensor is the only sensor connected to the SIB, that the SIB is turned on. Repeat the attempt to pair the sensor to the diver. Trouble shoot hardware connections as needed.
  - Click on the zero button on the row with the sensor serial number
  - If the sensor is successfully zero'd (no error message), proceed to the next diver
  - If there was an error attempting to zero the sensor, repeat the attempt to zero the sensor
    - If an error occurs during zeroing of a sensor, the Serial Number may be blanked out, and the Zero button made inaction – if this is the case, it is necessary to click on refresh to find the sensor and reactivate the button
  - Reconnect the cables for sensors that have been successfully paired.

Once this process has been completed for the number of divers that will be diving, the Sensor verification test can be performed if needed, otherwise close the Configuration Form.

Appendix F: Data Base Recovery Procedure

Database Recovery Procedure

To be performed on a laptop that a database is to be recovered to.

1. Ensure TDM Program is Closed
2. Open Windows Explorer to My Computer Window (Start->My Computer)
3. Click on local Disk “C”
4. Double click on “Program Files”
5. Double click on “TDMP” directory
6. Double click on “TDMDB” directory
7. Rename TDM.mdb file to read TDM<date>.mdb (use todays date in place of <date>; this is making a backup of the current file)
8. Leave the TDMDB window open and open a 2nd instance of Windows Explorer (Start->My Computer)
9. Insert the PCMCIA drive containing the backed up TDM database and files
10. Click to open the PCMCIA drive (D:, E:, or F:)
11. Highlight the two files with the most recent date by clicking in one, push shift and arrow up or down as needed. (file names will be identical except for the string ‘DAT’ added in one.
12. Drag files from backup directory to the TDMDB directory
13. In the TDMDB directory, double click on the filename not containing the string ‘DAT’ in the filename. The file extension with be ‘.ZIP’ to open the zip file.
14. Select the .mdb file from inside the zip file and drag it to the TDMDB directory.
15. Rename the just copied .mdb file to remove the date from the name, leaving it named “TDM.mdb”
16. Close all Windows Explorer windows
17. Start TDM by double clicking the icon on the desktop
18. Confirm that the last dive that was performed is on the machine by clicking on Operation.
19. Close Operation Data
20. Click to open Operation Roster, and confirm that all dives that were performed as part of this operation are present in the list of dives.
21. Close the TDM

Appendix G: Instructions for updating TDM executable

Instructions for Updating TDM Executable

The TDM executables have file name of VVAL18RT-<date>.exe, where <date> is the date the executable was compiled. This date can be used to ensure that the correct executable is being used.

Remove the desktop link to use the current executable.

- On the desk top select the current icon that is used to start the TDM with a single click of the left mouse button.
- Click the right mouse button once to bring up a menu
- Select Delete with a single click of the left mouse button
- Confirm the deletion by clicking Yes in the message box.

Access the CD drive, and copy the file from the CD to the directory C:\Program Files\TDMP. One method to accomplish this copy is:

- If the CD/DVD drive is not in the drive bay, swap the battery for the CD/DVD drive.
- Double click on the “My Computer” Icon
- In the window that is open double click on the name of the CD Drive.
- Highlight the name of the VVAL18RT-<date>.exe file
- While the name is highlighted press the right mouse button once which will bring up a menu
- select copy from the new menu with a single click of the left mouse button

- In the address bar click on the downward facing arrow at the far right to open up a list of file locations.
- Highlight the C: directory and click the left mouse button once.
- Double click the left mouse button on the directory “Program File”
- Double click the left mouse button on the directory “TDMP”
- From the horizontal menu at the top of the page, highlight Edit and click the left mouse button once. A pull down menu will appear.
- Select Paste with a single left click.
- The file is now in the correct location.

Add a link to the desktop link to use the new executable

- In the C:\Program Files\TDMP directory (should still be there from the copy) select the new executable name with a single click of the left mouse button.
- Click the right mouse button once to bring up a menu
- Highlight “Send To” with the mouse cursor which will bring up a side menu.
- Move the mouse cursor to the side and then down to “Desktop (create shortcut).
- Click the left mouse button once to create the shortcut on the desktop

- Locate the new shortcut on the desktop – this is the icon that is to be used to start the TDM